EFFICACY OF INSECTICIDES AGAINST PINK BOLLWORM *PECTINOPHORA GOSSYPIELLA* (SAUNDERS) IN BT COTTON

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ABSTRACT

***Pectinophora gossypiella* is a key pest of cotton responsible for causing huge economic loss to the cotton grower in India. After two decades of Bt cotton introduction, an outbreak of pink bollworm recorded during 2021 in Punjab. Insecticides are largely used to control pest infestation, In this regard, 21 insecticides recommended by Central Insecticide Board (CIB) including conventional and new generation insecticides were evaluated during 2020-2022. Spraying was initiated at reproductive stage of cotton (100 DAS) when pink bollworm cross 5% ETH level at an interval of 7-15 days. Emamectin benzoate 5SG (Proclaim) @ 100gm, fanpropathrin 10 EC (danitol) @ 300 ml, profenophos 50EC (curacron) @ 500 ml, spinetoram 11.7SC (delegate) @ 170 ml, indoxacarb 15SC (kingdoxa) @ 200 ml, chlorpyriphos 20EC (radar) @ 500 ml and cypermethrin 25EC (cyperguard) @ 80 ml were found most effective in reducing the pink bollworm. Among these, emamectin benzoate 5SG, indoxacarb 15SC, profenophos 50EC and spinetoram 11.7SC recorded significantly lower boll (5.92± 0.10, 4.67± 0.10) and locule damage (7.11± 0.42, 5.00± 0.32) at the time of harvesting along with higher seed cotton yield (21.58, 21.95 qtl/ha), respectively. Similarly, profenophos 50EC, emamectin benzoate 5SG and fanpropathrin 10EC cause more than 70 % larval mortality under laboratory conditions.**

Key words: Cotton, green boll damage, mortality, open boll and locule damage, insecticides, *Pectinophora gossypiella,* seed yield

Being long duration crop, cotton is vulnerable to various abiotic and biotic stresses that result in reduction of cotton yield. Among various biotic factors, insect pests are responsible for causing huge economic loss. Adoption of Bt cotton in 2002 led to drastic reduction in bollworm incidence (American, spotted and pink bollworm) and pesticide application in cotton agroecosystem. Afterwards, there was gradually increase in sucking pests and an outbreak of certain pests like mealybug (2005), whitefly (2015) and thrips (2017) were recorded in North India (Kumar et al., 2020). However, pink bollworm resistance on Bt cotton was reported from Gujarat (2015) and southern states in 2016 onwards (Kranti 2016). In 2019, resistance to Bt cotton was documented in the districts of Jind, Haryana, and Bathinda, Punjab. This development subsequently led to significant losses for cotton growers in North India. Pink bollworm *Pectinophora gossypiella* Saunders (Lepidoptera: Gelechiidae) is a serious pest during non-Bt cotton era (Amin and Gergis, 2006). It is native to Asia and first described in 1843 by Saunders from the infested cotton bolls in India (Maruti et al., 2020). It is responsible for causing both quantity and quality losses in recent years and emerged as threat to cotton cultivation due to the breakdown of resistance in Bt cotton. It is a stenophagous pest, known to feed on malvaceae crops and lay eggs on tender leaves, flower and bolls (Madhu and Murli Mohan, 2022). The hatched larvae feed on flowers and green bolls reducing both quantity and quality of harvested lint and seeds by (30-40% losses) during late season (Zaki, 2012). The favourable conditions for multiplication of PBW under was 28:30°C as Harshvardhan et al., (2024) reported high fecundity and survivability (egg, larval and pupal) of PBW on this alternate temperature combinations. The insecticides remained the primary method of pest control, particularly for bollworms (Mohamed et al., 2010). Many conventional insecticides are being used by the cotton growers to manage pink bollworm; yet, effectiveness against pink bollworm is not satisfactory. Keeping in view the above facts in mind, new generation insecticides along with conventional insecticides were evaluated for their efficacy against pink bollworm on Bt cotton in Punjab.

MATERIALS AND METHODS

Various new generation and conventional insecticides having varied mode of action were evaluated against pink bollworm on Bt cotton under field conditions at three locations namely Bathinda, Mansa and Fazilka districts of Punjab, India during kharif 2020, 2021 and 2022. An area of 500 m^2 was kept for each treatment with three replications each. The Bt cotton cultivar, RCH 773 was used in this experiment. The spraying was done with knapsack sprayer using 375 liters of water per hectare at 5% economic threshold level of pink bollworm. The observations on per cent damage caused by PBW on flowers, green boll and open boll basis and loculi basis damage at harvest time was recorded as per the standard protocol. PBW larvae per 20 green bolls at weekly interval were also recorded. The seed cotton yield was recorded on whole plot basis and later convert to quintals per ha. Laboratory trial was also conducted from the selected insecticides to know the mortality under control conditions (28^0C± 75%). Ten days old green bolls were taken as substrate to conducted laboratory experiments. The bolls were treated with field dose insecticides and exposed to PBW larvae for feeding as food and record the mortality of larvae after an exposure period of 3 and 7 days. The moribund larva was considered as dead. The data was subjected to one way ANOVA after appropriate transformation using CPCS1 analysis programme (Cheema and Singh 1990). For laboratory trials, the result was expressed as corrected mortality using Abbott's formula (Abbott 1925).

RESULTS AND DISCUSSION

Field trails: The research trial conducted at Bathinda and Abohar during 2020 and 2021 revealed that per cent flower damage due to pink bollworm (PBW) did not differ significantly in all the treatments before application of insecticides The pooled analysis of research trials conducted during 2021 and 2022 cotton crop season at three different locations in Bathinda and Abohar revealed that various insecticides were found effective against PBW (Table 1). After third spray at an interval of 7 days, chlorpyriphos 20EC, cypermethrin 25EC, emamectin benzoate 5SG, indoxacarb 15SC, profenophos 50EC and spinetorum 11.7SC recorded less than seven % PBW larval incidence in green bolls and was significantly better than all other treatments and were found to be at par with each other. Similarly after sixth spray, emamectin benzoate 5SG recorded only 5.5% larval incidence in green bolls followed by chlorpyriphos 20EC and fanpropathrin 10EC, spinetorum 11.7SC, cypermethrin 25EC and profenophos 50EC. Open boll basis damage at harvest, it was observed that cypermethrin10EC, deltamethrin, emamectin benzoate 5SG, indoxacarb 15SC, profenophos 50EC and spinetorum 11.7SC recorded less than 7% open boll damage on boll basis at the time of harvest and was significantly managed the pest as compared to other treatments. On locule basis, cypermethrin 25 EC, emamectin benzoate 5SG, flubendamide 480SC, indoxacarb 15SC and spinetorum 11.7SC showed significantly lower damage as compared to all other treatments.

Laboratory experiment: When PBW larvae were exposed to treated bolls of 3 days after treatments, it was observed that profenophos 50EC was significantly better than other treatments and recorded 79± 1.38 % larval mortality (Fig. 1). Emamectin benzoate 5SG, fanpropathrin 10EC and spinetorum 11.7SC were

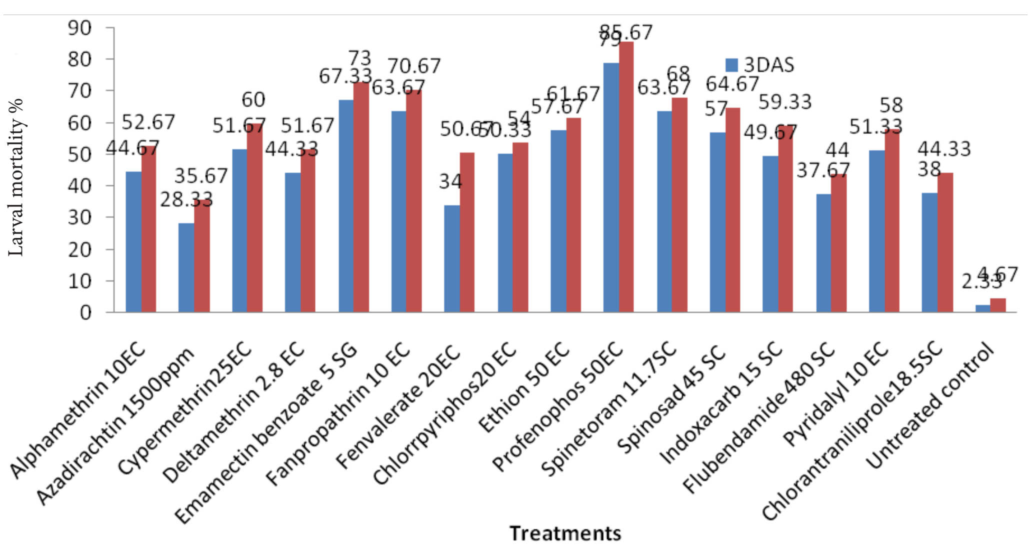

Fig. 1. Efficacy of different insecticides under laboratory conditions against pink bollworm in cotton during 2021 at PAU, Ludhiana

Table 1. Efficacy of insecticides against Pink bollworm on Bt cotton (kharif 2021, Abohar; 2022, Bathinda) (Pooled data)

Treatment	Dose (ml or g/acre)	Per cent PBW larval incidence in green bolls (20 boll basis) (Mean± SE)							Open boll damage at harvest (%)	
		105 DAS	113 DAS	120 DAS	128 DAS	135 DAS	142 DAS	150 DAS	On boll basis	On locule basis
Alphamethrin 10EC (Alphaguard)	100	7.00± 0.26 (15.09)	5.50± 0.34 (13.33)	9.25± 0.99 (17.69)	8.83± 0.35 (17.00)	9.58± 0.17 (17.39)	8.83± 0.17 (17.22)	8.83± 0.32 (17.09)	9.83± 0.17 (18.15)	14.90± 1.00 (22.68)
Azadirachtin 1500ppm (Nimbecidine)	1000	8.50± 0.35 (16.59)	8.50± 0.44 (16.88)	11.75± 0.17 (20.03)	14.06± 0.44 (21.05)	19.72± 0.56 (24.86)	22.75± 0.35 (28.32)	25.50± 0.68 (29.91)	18.50± 0.39 (25.43)	41.95± 5.68 (40.24)
Bifenthrin 10 EC	800	8.57± 0.28 (16.77)	8.08± 0.39 (16.72)	12.75± 0.36 (20.84)	11.97± 0.38 (19.68)	13.42± 0.12 (20.57)	14.50± 0.32 (22.30)	14.67± 0.24 (22.36)	15.83± 0.44 (23.41)	15.02± 4.20 (22.78)
Beta-cyfluthrin 0.25 SC (Bulldock)	300	7.00± 0.23 (15.25)	5.50± 0.12 (13.56)	7.50± 0.23 (15.81)	9.50± 0.23 (17.31)	11.08± 0.23 (18.76)	11.72± 0.42 (19.99)	12.08± 0.22 (20.22)	11.67± 0.42 (19.95)	27.91± 2.17 (31.86)
Chlorpyriphos 20 EC (Radar)	500	7.13± 0.09 (15.03)	6.00± 0.43 (13.79)	7.13± 0.32 (15.38)	6.92± 0.12 (14.99)	5.67± 0.15 (13.42)	6.08± 0.21 (14.18)	6.42± 0.09 (14.53)	6.50± 0.10 (14.74)	7.26± 0.68 (15.60)
Chlorantraniliprole 18.5SC (Coragen)	60	7.25± 0.07 (15.50)	8.38± 0.24 (16.57)	13.75± 0.36 (21.75)	10.42± 0.10 (18.42)	10.92± 0.16 (18.73)	8.00± 0.56 (16.39)	7.75± 0.06 (16.13)	8.00± 0.14 (16.42)	8.24± 0.84 (16.64)
Cypermethrin25EC (Cyperguard)	80	5.75± 0.44 (13.71)	4.38± 0.58 (12.01)	6.63± 0.17 (14.72)	6.42± 0.08 (14.45)	5.25± 0.08 (13.00)	7.92± 0.42 (16.25)	8.08± 0.12 (16.47)	6.67± 0.12 (14.96)	4.91± 0.68 (12.78)
Cypermethrin10EC (Ripcard)	200	7.63± 0.10 (15.74)	6.75± 0.25 (14.89)	9.00± 0.22 (17.44)	9.42± 0.21 (17.39)	10.67± 0.16 (18.36)	10.58± 0.68 (18.88)	11.08± 0.16 (19.27)	6.17± 0.09 (14.36)	7.24± 0.35 (15.58)
Deltamethrin 2.8 EC (Deltamethrin)	160	8.25± 0.12 (16.46)	6.88± 0.44 (15.12)	9.00± 1.06 (17.44)	8.75± 0.13 (16.93)	8.00± 0.24 (15.90)	12.42± 0.48 (20.56)	11.42± 0.12 (19.49)	5.56± 0.06 (13.62)	7.43± 0.24 (15.79)
Ethion 50 EC (Fosmite)	800	8.25± 0.21 (16.57)	6.88± 0.28 (15.15)	9.25± 0.45 (17.66)	10.08± 0.28 (18.17)	11.00± 0.42 (18.85)	13.75± 0.62 (21.67)	13.33± 0.22 (21.30)	11.17± 0.13 (19.51)	18.11± 0.12 (25.17)
Emamectin benzoate 5 SG (Proclaim)	100	6.25± 0.08 (14.24)	5.13± 0.08 (12.19)	5.75± 0.52 (13.53)	5.08± 0.16 (12.92)	4.83± 0.09 (12.33)	5.50± 0.22 (13.45)	5.92± 0.08 (13.89)	5.75± 0.20 (13.85)	5.11± 0.07 (13.06)
Fanpropathrin 10 EC (Danitol)	300	6.88± 0.13 (14.92)	5.50± 0.15 (13.39)	7.50± 0.42 (15.85)	6.08± 0.12 (14.06)	5.50± 0.13 (13.22)	6.08± 0.12 (14.12)	6.42± 0.12 (14.51)	7.00± 0.12 (15.33)	6.50± 1.00 (14.75)
Fenvalerate 20EC (Markfenvel)	100	7.25± 0.16 (15.50)	6.00± 0.27 (14.17)	8.20± 0.68 (16.57)	9.22± 0.35 (17.37)	9.20± 0.22 (17.23)	8.00± 0.09 (16.36)	7.96± 0.10 (16.32)	9.33± 0.18 (17.77)	19.35± 1.12 (26.07)
Flubendamide 480 SC (Fame)	40	7.75± 0.13 (15.99)	8.50± 0.42 (16.77)	12.00± 0.89 (20.24)	12.83± 0.28 (20.12)	15.42± 0.42 (22.01)	10.83± 0.16 (19.20)	10.67± 0.18 (19.05)	18.33± 0.58 (25.32)	39.93± 0.48 (14.29)

(contd.)

(contd. Table 1)

Indoxacarb 15 SC (Kingdoxa)	200	6.75± 0.20 (14.85)	5.75± 0.22 (13.79)	6.88± 0.27 (15.12)	7.50± 0.12 (15.73)	7.25± 0.23 (15.23)	9.33± 0.20 (17.45)	9.00± 0.20 (17.38)	5.17± 0.05 (13.13)	5.47± 0.56 (13.51)
Profenophos 50EC (Curacron)	500	7.13± 0.11 (15.26)	4.63± 0.25 (12.40)	6.08± 0.24 (14.15)	6.80± 0.10 (14.96)	6.25± 0.14 (14.08)	8.06± 0.22 (16.45)	7.89± 0.23 (16.26)	5.92± 0.10 (14.06)	7.11± 0.42 (15.45)
Pyridalyl 10 EC (Sumipleo)	300	8.38± 0.68 (16.62)	7.75± 0.68 (15.95)	11.13± 0.58 (19.47)	11.67± 1.20 (19.27)	13.75± 0.48 (20.81)	9.67± 0.14 (18.08)	9.50± 0.12 (17.91)	14.67± 0.14 (22.49)	33.07± 4.10 (35.07)
Spinetoram 11.7SC (Delegate)	170 ml	7.63± 0.44 (15.74)	5.63± 0.44 (13.61)	6.58± 0.35 (14.78)	6.67± 0.12 (14.84)	5.88± 0.22 (13.79)	6.08± 0.08 (14.06)	6.75± 0.08 (14.80)	4.67± 0.10 (12.44)	5.00± 0.32 (12.91)
Thiodicarb 75 WP (Larvin)	250	7.88± 0.32 (16.07)	7.75± 0.28 (16.16)	7.50± 0.21 (15.89)	9.88± 0.22 (17.82)	9.51± 0.16 (17.37)	11.50± 0.23 (19.80)	10.54± 0.14 (18.89)	10.50± 0.12 (18.89)	14.29± 0.56 (22.16)
Spinosad 45 SC (Tracer)	60	9.00± 0.56 (17.39)	9.13± 0.15 (17.57)	11.13± 0.20 (19.43)	13.58± 0.56 (21.03)	13.92± 0.24 (21.14)	12.83± 0.18 (20.96)	13.13± 0.28 (21.17)	16.17± 0.10 (23.06)	32.64± 2.63 (34.75)
Untreated control	--	13.13± 0.68 (21.21)	20.75± 0.27 (27.09)	25.75± 1.18 (30.44)	26.33± 2.20 (29.59)	30.92± 0.14 (32.79)	34.33± 1.20 (35.64)	34.79± 0.84 (36.06)	30.33± 0.99 (33.38)	45.60± 4.34 (42.42)
LSD (p=0.05)	--	(2.85)	(3.36)	(2.27)	(4.84)	(4.84)	(3.07)	(3.50)	(1.41)	(1.78)

DAS: Days after sowing, Figures in parentheses arc sine transformed values

at par with each other and recorded more than 60% mortality whereas spinosad 45SC and indoxacarb 15SC and cypermethrin 25EC observed 50% mortality. Similarly, profenophos 50EC recorded 85.67±0.30 % larval mortality and was significantly superior to all other treatments. After seven days of treatment, profenophos 50EC recorded 85.67% mortality followed by emamectin benzoate 5SG, fanpropathrin 10EC and spinetorum 11.7SC (73.00± 1.16, 70.67± 1.24 and 68.00± 1.18%) larval mortality and were at par with each other in comparison to all other treatments (Fig 1). Among all the treatments, indoxacarb 15SC, emamectin benzoate 5SG, cypermethrin 25EC, profenophos 50EC and fanpropathrin 10EC were at par with each other and found significantly better than all other treatments giving more than 22.00 quintal per ha cotton yield (Table 2)

Screening old and new chemistry molecules will help to select the effective insecticide against *P. gossypiella*. Among various insecticides tested, deltamethrin 2.8EC, emamectin benzoate 5SG, indoxacarb 14SC, profenophos 50EC, thiodicarb proved effective in reducing PBW incidence and recorded higher seed cotton yield. Sarode et al., (2019) corroborate our findings and reported that spray of chlorantraniliprole 18.5SC prove effective in recording minimum green boll damage and fallen materials which was at par with emamectin benzoate 5SG, spinosad 45SC and thiodicarb 75WP at Parbhani, Maharastra. Sasikumar and Vimala (2020) revealed spinosad 45SC @ 250 ml/ ha as most effective insecticides against pink bollworm followed by chlorantraniliprole 18.5SC @ 150 ml/ ha recording lowest rosette flower incidence, green boll damage and locule damage at the time of harvesting and also recorded highest seed cotton yield. Sarma et al., (2020) finding support our results and reported that spinetoram 10% + sulfoxaflor 30% WG @ 350 ml/ ha, pyriproxyfen @ 750 ml/ ha and sulfoxaflor @ 300 ml/ha were effective in reducing the pink bollworm damage in green bolls along with highest yield. Pathan et al., (2021) recorded chlorantraniliprole 18.5SC highly effective against pink bollworm and recorded 7.44% rosette flower and 8.78% green boll damage and reported at par with spinetoram 11.7 SC and lamda cyhalothrin 5EC at par at the time of harvesting. Mahalakshmi and Prasad (2021) results were in line with our findings as they conducted experiment at Guntur and reported that cypermethrin 25 EC @ 500 ml/ha and bifenthrin 10EC @ 800 ml/ha were effective over the thiodicarb 75WP and profenophos 40EC and also reported that spinosad 45SC, emamectin

Table 2. Effect of various insecticides used against pink bollworm on seed cotton yield

Treatment	Dose (ml/ acre)	Seed cotton yield (q/ ha)			
		Bathinda		Abohar	Pooled
		Exp 1.	Expt 2.	Expt 3.	mean
Alphamethrin 10EC (Alphaguard)	100	16.46	18.09	18.58	17.71
Azadirachtin 1500 ppm (Achook)	1000	13.89	14.68	15.06	14.54
Bifenthrin 10EC	800	17.00	17.65	18.00	17.55
Beta-cyfluthrin 0.25SC (Bulldock)	300	15.74	16.06	16.56	16.12
Chlorpyriphos 20EC (Radar)	500	21.21	21.71	21.57	21.49
Chlorantraniliprole18.5SC (Coragen)	60	18.24	18.63	18.80	18.55
Cypermethrin25EC (Cyperguard)	80	21.64	22.31	22.31	22.08
Cypermethrin10EC (Ripcard)	200	20.12	20.62	20.60	20.44
Deltamethrin 2.8EC (Decis)	160	21.86	22.84	22.57	22.42
Ethion 50EC (Fosmite)	800	16.64	17.24	17.69	17.19
Emamectin benzoate 5SG (Proclaim)	100	21.82	22.35	22.67	22.28
Fanpropathrin 10EC (Danitol)	300	22.42	20.07	21.83	21.44
Fenvalerate 20EC (Markfenvel)	100	16.52	17.10	17.68	17.10
Flubendamide 480SC (Fame)	40	14.02	14.29	15.34	14.55
Indoxacarb 15SC (Kingdoxa)	200	22.31	22.83	22.98	22.70
Profenophos 50EC (Curacron)	500	19.86	22.90	21.99	21.58
Pyridalyl 10EC (Sumipleo)	300	15.31	15.85	15.68	15.61
Spinetoram 11.7SC (Delegate)	170	22.52	21.50	21.84	21.95
Thiodicarb 75WP (Larvin)	250	18.48	20.97	20.12	19.85
Spinosad 45SC (Tracer)	60	14.21	14.96	15.32	14.83
Untreated control	--	10.30	8.75	10.30	9.78
LSD (p=0.05)	--	2.25	1.88	1.39	1.01

benzoate 5SG and chlorantraniliprole 20SC effective in reducing larval population of pink bollworm along with lower boll damage (Kumar et al., 2023). As most of the insecticides selected for this study were contact, stomach poison and neurotoxin found highly effective against PBW. As old chemistry molecules have high doses and long persistent but new chemistry insecticides have low dose and high efficiency in managing the *P. gossypiella*. Among the tested insecticides, proclaim 5SG, fanpropathrin 10EC, chlorpyriphos 20EC, spinetoram 11.7SC, chlorantraniliprole 18.5SC, profenophos 50EC, cypermethrin 25EC and indoxacarb 15SC recorded significant low per cent green boll damage, open boll damage and loculi damage at harvest and higher seed cotton yield as compared to all other treatments. Shankar et al., (2022) and Naik et al. (2023) also support our finding and reported that emamectin benzoate 5 SG, chlorantraniliprole 18.5 SC and spinosad 45 SC being part of IPM found effective in suppressing PBW larvae with minimum green boll, open boll and locule damage. Similarly under laboratory conditions profenophos 50EC, emamectin benzoate 5SG and fanpropathrin 10EC recorded high mortality of *P. gossypiella* alongwith higher seed cotton yield. These insecticides can be alternatively rotated to manage pink bollworm in cotton.

ACKNOWLEDGEMENTS

Authors are thankful to Head, Department of Entomology, Punjab Agricultural University, Ludhiana for providing necessary facilities for carrying out the study.

FINANCIAL SUPPORT

No funding received..

AUTHOR CONTRIBUTION STATEMENT

J K, J K, J K and M P: conducted trials. V K, A K, V J and N S: provided technical guidance, inputs, conducted trials and analysed the data, compiled the results and critically wrote and revised the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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(Manuscript Received: May, 2024; Revised: September, 2024;
Accepted: September, 2024; Online Published: October, 2024)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e24298